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THE

A. B. C. SEWAGE PROCESS;

BEING A

REPORT OF THE EXPERIMENTS

HITHERTO MADE AT

LEICESTER, TOTTENHAM, AND LEAMINGTON,

ON THE

PURIFICATION AND UTILIZATION OF SEWAGE.

PUBLISHED BY SPECIAL REQUEST.

LONDON:
ELLIOT STOCK, 62, PATERNOSTER ROW.

Having received many requests to publish an account of the Leicester experiments on the A. B. C. process, we have thought it best to issue this pamphlet, in which we have candidly given our opinions and experience on the subject, in order to furnish the public with the necessary information to enable them to form a judgment on the process.

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62, Cornhill,
9th October, 1868.

THE

A. B. C. SEWAGE PROCESS.

THE great sanitary problems of the day are acknowledged to be, the purification of the water we drink, and the disposal of the sewage of our towns; and, when we consider that sewage is the principal source of the pollution of our rivers, we must admit that of these two problems the latter is of primary importance. Wherever men congregate, it becomes essential to devise some means of carrying away the excreta and refuse; and, all points considered, no method of doing this is so cheap, convenient, and expeditious as water carriage, or, as it is commonly called, town sewerage. Various suggestions have nevertheless been made to avoid this, but the great expense of working these schemes, and the nuisance created by them, have proved almost effectual obstacles to their general adoption. In viewing the question, we must bear in mind that nearly all our large towns are already sewered, and what we have to do is to treat the fluid discharged

by the sewers, and, to treat it in such a way as to prevent any of its deleterious ingredients from passing into the rivers, and, at the same time, to retain all that is valuable, for agricultural purposes, in such a form as shall be no bar to its practical application.

The large quantity of sewage (on the average nearly 30 gallons per head per day) and its consequent dilution have, hitherto, been a serious obstacle to its useful application; for we must bear in mind that no scheme can be considered successful, which does not utilize in some form or other the greater part of the valuable ingredients contained in it. These elements have been originally derived from the soil, and to the soil they must be returned, if we would avoid impoverishing and ruining it.

The plans hitherto attempted may be classed under three heads—Irrigation, Filtration, and Precipitation.

Irrigation has many advocates, and is in practice in several localities—Edinburgh and Croydon, for example—but its disadvantages are by no means inconsiderable, such as the application to a small area of what ought to be a benefit to a very large one, and the risk of propagating sickness or disease by the application to the surface of the soil of what should be buried beneath it, and, consequently, the presence of noxious exhalations from the irrigated land, and the tape-worms and other entozoa that adhere to the crops themselves.

It is a very significant fact that the chief advocates of irrigation have contented themselves with stating the *total* amount of solid impurity left in the effluent water, omitting to distinguish inorganic from organic matter, though the latter is the only injurious component present, the mineral matter being, as a rule, perfectly harmless.

Filtration—Of the systems dependent upon this alone, but few words are requisite. By this means the poisonous organic matter held in solution cannot be removed; the only substances arrested being those which would settle to the bottom if sufficient time were allowed. We are therefore forced to the conclusion that the only effective method is by precipitation, should an agent be found which would clarify the water sufficiently to allow its running into the rivers without unduly polluting them, and at the same time retain in their integrity the nitrogen and phosphates which, it is well known, constitute the principal fertilizing properties of sewage.

Precipitation—Various agents have been from time to time proposed for this purpose. The principal has been, Alum, long used by the Chinese, but patented by Pinel in this country in 1842, and since then in various forms by more than a dozen other inventors. In outward appearance the action of this substance is satisfactory, but when the supernatant water is submitted to analysis, it is found to contain all the soluble organic matters originally

present in the sewage. The only substances precipitated, as shown by Professor Way's analysis, being those which would have been separated by an efficient system of mechanical filtration; alum alone is, therefore, useless.

Next followed Wicksteed's Patents for Lime and Charcoal, and Higgs' for Lime alone. Both these processes were tried on a large scale—the former at Leicester, the latter at Tottenham. But the result in both cases was an unsatisfactory purification of the water, and the production of a large quantity of residuum which the farmers refused to use, because its principal ingredient was carbonate of lime, and it was almost wholly deficient in the nitrogen and phosphates in which the value of the manure really consists. After a trial of some years, the Leicester company handed their works over to the corporation, who continue to carry them on at a considerable annual expense. The Tottenham works also reverted to their Local Board of Health, and they still carry on a lime process, the results of which have been a Chancery suit and an injunction.

Perchloride of iron and Carbolic acid have also been proposed and tried for this purpose. The former removes the sulphuretted hydrogen, to which the smell of the sewage is mainly due, but leaves untouched all the dangerous organic impurities. The latter acts mainly as a cloak, by its own more powerful odour concealing that of the sewage.

These agents have also been tried in various combinations, but with little more success.

In this state the subject stood in May, 1868, when the extremity to which the Tottenham Board had been driven by the granting of the injunction led to an application to us, through Mr. Jones, of the Ratepayers' Association, for the results of some experiments which we were then carrying on on this subject. The full details of the process were at once laid before him, and the result was an arrangement for experiments on a somewhat large scale at Tottenham, which was the first public trial of the A. B. C. process.

The A. B. C. mixture (so called from the initials of the three principal ingredients—Animal-charcoal, Blood, and Clay) is a compound which, when dissolved in either sewage or water, and added to the sewage, produces an immediate precipitation of the greater part of the injurious matter in the form of large flakes, which rapidly fall to the bottom; the supernatant liquor being then allowed to flow into a tank, a small quantity of a solution of perchloride of iron is added to it, and this precipitates the sulphuretted hydrogen dissolved in the water, and removes the last traces of smell.

In addition to these four ingredients, it has been found desirable to add a proportion of alum, as, although the same degree of purity could be

obtained without its use, the process is very much accelerated by it, and this more than compensates for the addition of a small quantity of harmless mineral matter to the water. Nothing is used which can dissipate or discharge any of the ingredients which are of value ; on the contrary, the larger part of the ammonia and all the phosphates are fixed in the residuum, together with about four-fifths of the organic impurities, the deposit, of course, being of great agricultural value, requiring only the addition of a small quantity of acid to render it fit for sale to the farmer.

The first experiment at Tottenham took place on the 19th May last, and was on about 5,000 gallons. The effluent water was sufficiently pure to justify further experiments, and accordingly on May 30th about 70,000 gallons were treated.

34,542 gallons of this were allowed to flow into a large tank, the A. B. C. compound running in at the same time from two small tubs. About 70 gallons of the solution were used. Another 35,000 were then treated in a small tank holding only 5,000 gallons, the object being to prove that the deposit from one lot of, say 5,000 gallons of sewage, possessed the power of precipitating the impurities from 5,000 gallons more; and that, with a very small addition of A. B. C.—not more than 10 per cent. of the quantity originally used—the same power was retained to the fifth time of using it; the purity of the effluent water was

nearly the same, and the manure increased in percentage of ammonia every time. This trial was extremely satisfactory, and proved that the preliminary experiments had been correct. In this experiment no attempt was made to separate the heavier deposit of silica from the lighter and more valuable particles of the manure. By a very simple mechanical arrangement made during subsequent experiments this was satisfactorily effected. The analyses of the sewage, effluent water and manure from these experiments are given in a separate table at the end.

These trials having been brought to the notice of Sir W. Denison, that gentleman called at 62, Cornhill, and there saw sewage, from the outfall at London Bridge, operated upon by A. B. C., in a manner so satisfactory, as to induce him to request us to undertake, for the satisfaction of the Royal Rivers Commission, a trial on a large scale for the purpose of demonstrating that it was as practicable as it appeared to be. In pursuance of this suggestion, and at the request of the Home Secretary, the Mayor of Leicester courteously placed the Abbey Meadow Sewage Works at our disposal, and as these works are in duplicate, so arranged it, that whilst the sewage in one set of tanks was being treated with the A. B. C. compound, the other set continued to work on the milk of lime process; by this means giving an opportunity of comparing the results of the two.

This trial, conducted, like the others, at our own expense, lasted from July 25th to August 1st, six days in all, during which period upwards of ten million gallons passed through each set. The trial was a most severe one, considering the absence of all experience in dealing with the refuse of a manufacturing town, containing not merely human excreta, but dyes, mordaunts, soap (in large quantities), and various other refuse matters, and the great rate at which (during the busy part of the day) it was necessary to purify this, a rate of not less than 2,500 gallons per minute through each set of tanks. Still our confidence in the *principles* of the process made us at once accept the responsibility of what the scientific journals properly called the application of a *breaking strain.* During the experiment the correctness of this phrasc received remarkable confirmation. Mechanical difficulties, due to the fact that the pumps and tanks, although admirably suited for thc lime process, were not so well calculatcd to work the A. B. C., continually arose. The temporary dam, erected between the two sets of tanks, was on more than one occasion breached by the wash of the sewage, and stoppages of several hours werc necessary to repair these injuries. Besides this, great quantities of sewage, and (what was even more prejudicial) of sewage treated with lime were allowed to mix with the A. B. C. water, thereby liberating a very considerable portion of the organic matter and

ammonia which had been carried down, and conversely allowing a portion of the A. B. C. mixture to act on the lime-purified water, *from which it threw down a further precipitate*, thus rendering their water purer than usual.

It was singularly unfortunate that the most serious of these accidents happened on one of the days when the samples were being taken by the Royal Commission. The dam between the tanks being washed away, about 150,000 gallons of sewage were allowed to flow into the A. B. C. tank, utterly vitiating any results obtained on that day, since the A. B. C. effluent water was mixed with nearly its own volume of sewage.

As an illustration of the injurious effects produced by the accidents to the dam, an analysis marked with a star may be pointed out. This sample, which was taken *during the visit of the Royal Commission*, contained nearly as much sewage as purified water. It is not to be wondered at that it contains 18 grains per gallon of organic matter. To give analyses of more of such samples as this would be useless.

No river *could* object to receive water containing only ten grains per gallon of organic matter, and it will be noticed that several of the Leicester samples contained but a small fraction over seven grains.

The *Times* of the 4th of August contained a full report of the experiment, and of the difficulties

overcome, and the concluding paragraph of that report was as follows:—

"The Leicester experiments are not yet completed, but we have said enough to show the importance of the pending inquiry, whether this new invention really is a marvellous boon to the world, or whether the whole is an illusion or a sham."

On this point the public can now decide.

In order to enable those interested in the subject to satisfy themselves upon this point, we have made analyses of the results of the trial, and, to facilitate comparison, arranged them in tabular form, where the figures may be compared. As an additional fact bearing upon the question, it may be interesting to know that a sample of a gallon of the effluent water still stands in our Cornhill office, perfectly clear and sweet, containing fish put in some weeks since.

In regard to the *mode* of working this process, we cannot do better than describe the arrangements made at Leicester.

The charcoal, blood, clay, and alum, with small quantities of gypsum, and one or two other ingredients, were allowed to soak in water for about one hour, in a tank holding some 800 gallons. At the end of that time they were allowed to flow into a circular well on the same level as the bottom of the sewer. An agitator, revolving in this well, kept the mixture in a state fit for use. Attached to each of the pumping engines, which

pumped about 200 gallons of sewage per stroke, was a small pump drawing from this well and throwing about $1\frac{1}{2}$ gallons per stroke. These two pumps delivered their respective liquids into a culvert leading to the settling tanks, a perfect mixture being produced by a small agitator placed in this culvert. The sewage was about two hours in passing through the tanks, but in far less time than this all the suspended matter had fallen to the bottom and the water was clear. The precipitating tank was divided transversely into two parts, and at the division a small quantity of a very dilute solution of perchloride of iron was allowed to drip in; this precipitated the sulphuretted hydrogen, and entirely freed the water from smell. It then passed on through the other tank, and ran over a dam into the river Soar.

In order to use the mud over again, it was raised by elevators from the bottom of the tanks and allowed to flow into the mixing pit, thence to be again pumped into the tanks. Owing to the large size of the Leicester tanks and the comparatively short duration of the experiment, *a very small quantity only was thus used a second time;* it being obviously impossible to pump the mud out until the bottom of the tank was covered to some depth with it; consequently the Leicester manure is not so rich in nitrogenous compounds as it would have been even had the process been carried out in its integrity. The process is thus extremely

simple and applicable, requiring only very small alteration in the existing arrangements of most sewered towns.

In some respects the circumstances of Leicester are peculiar, the sewage has all to be pumped from a considerable depth below the surface. In the majority of instances this would be unnecessary, and the mechanical arrangements would be much simplified. It is only necessary to allow the compound to flow in at a regulated rate, and to cause an intimate admixture by an agitator.

Independently of the sanitary point of view, this question is of considerable importance in both a financial and agricultural sense—for whereas none of the other processes can be carried on without considerable pressure upon the ratepayers, the A. B. C. plan promises to be a source of revenue. Unlike the lime process, which, by dissipating the ammonia into the air, leaves a worthless deposit, the A. B. C. system retains the fertilizing properties of the sewage ; and unlike irrigation, which involves the serious responsibility and expense of leasing large tracts of land, it promises considerable revenue with but little outlay of capital.

There is not one of the ingredients, excepting the perchloride of iron, that does not positively add to its agricultural value, and therefore the residuum possesses, as the analysis shows, a character closely resembling guano, and eminently adapted to farming purposes. The quantity of animal char-

coal added is not sufficient to add materially to the amount of phosphates in the residuum, that being derived from the sewage itself. A considerable portion of that obtained from Leicester has been sold on the London Exchange at 70s. per ton—a price which seems fully justified by the fact of its containing 4½ per cent. of ammonia.

The actual result may be summed up as follows:—

1st.—The sewage contained 43.02 grains per imperial gallon of organic matter. Of this the A. B. C. process precipitated 33.33 grains, leaving only 9.69 grains in the water, and this from an average of fifty samples taken at intervals during the progress of the experiment.

2nd.—Hitherto the lime process has been acknowledged to be the best, and the Leicester mode of conducting it to be the best of its kind. The A. B. C. contrasts most favourably with this, inasmuch as, from samples taken at the same time from each, the water contained as follows:—

Water from the	A. B. C.	contained	9.69	grains	per imp.	gallon.
,,	,,	lime	,,	16.18	,,	,,	,,

having precipitated from the sewage the following proportions:—

Organic matter	precipitated	by the	A. B. C.,		77.48	per cent.
,,	,,	,,	,,	lime	62.39	,,

3rd.—Of the Nitrogen in the form of Ammonia in the sewage, nearly all is dissipated by the lime process, but by the A. B. C. about 80 per cent. was retained in the residuum.

4th.—Of the Phosphates in the sewage, the lime process threw down 82 per cent., in a form unavailable, owing to the presence of lime; but the A. B. C. threw down the whole, and in a form readily available.

5th.—During the act of precipitation by the A. B. C. process there was no objectionable odour, whilst that from the lime was "horribly offensive," owing, of course, to the ammonia and other gases being driven into the air by the lime.

6th.—The water from the A. B. C. is in no way detrimental to fish in the river. We have fish which have been for some weeks living in the purified sewage of Leicester.

7th.—By the A. B. C. process restitution can be made to the soil, by preparing in suitable form for putting *into* it (not *on* to it) what has been so freely given by it.

8th.—It solves the difficulty of which the Thames, at Barking, is an example. What is now an offence and an alarming deposit in the river, can be converted into a portable inoffensive material, of the value of which an estimate may be formed from the fact that in the Thames alone there is deposited London sewage which, according to the estimates of Professor Liebig and other eminent chemists,

has a money value of rather more than £4000 per day, or £1,500,000 per year. More than three-fourths of this manure would be utilized by the A. B. C. process, at an expense of not more than one-fourth of its actual money value.

Since the Leicester experiments were concluded, two small experiments have been made at Leamington. About 60,000 gallons were purified. The analyses of the sewage and effluent water are appended to this Report.

We are somewhat unwilling to introduce into this Report any valuation of the residuum made from the sewage; but we may mention the facts that two independent analyses give valuations of £3 17s. 3d., and that Dr. Frankland's estimate of a sample allowed to dry without the necessary addition of acid, whereby a large portion of the ammonia was lost, is (even then) £1 13s. $0\frac{3}{4}$d. per ton! These facts speak for themselves as to the profit to be derived from the process.

In an agricultural point of view, it is an acknowledged fact that, in order to retain the full fertilizing properties of the soil, it is requisite to restore to it all that is so freely given by it. Up to this time the soil has not had fair play, for we have been giving to the sea what we have been taking from the land, and trying, at great expense, to supply the deficiency by foreign importation. In *our* process we have aimed at restoring not merely the usual ingredients of sewage, but the blood, the most highly

organized compound known—in fact, the life itself. To use this for any purpose but manure is to deprive the soil of that which, more than anything else, will fertilize it.

Our object in investigating the matter has been to find the solution of this most important problem—to avert the slow but certain impoverishment of our English soil, and to endeavour to save the hundreds of lives now sacrificed to pestilence.

Our process is now before the public. *We* are fully satisfied with its results. If any other process does better, we heartily wish it success; but till we see some probability of this, we unhesitatingly say, that as the A. B. C. process will not only answer this purpose, but convert an annual outlay into a certain revenue, a great step has been taken in the right direction.

Since this Pamphlet was in the Printer's hands, the following letter has been received from Mr. Rochford, Florist, of Tottenham, to whom the first prize for Pines was awarded at the Autumn Show at the Crystal Palace:—

(Copy.)

Page Green, Tottenham,
Oct. 21, 1868.

Mr. Sillar.

Sir,—I have pleasure in stating that I have used the deposit obtained from the Tottenham Sewage Works by your patent process, mixed with the soil in which I potted a large number of pineapple plants, and I am much astonished and pleased with the result. There is a very *remarkable difference* between those and the other pine plants potted in soil mixed with crushed bones, and well-decomposed dung. The leaves are very broad, stiff, and intensely green, and altogether larger than the other plants *double the age.* I never before had pines look so well, and consider the sewage deposit you prepared, as of considerable value, and would feel pleased in showing these results to any gentleman wishing for an inspection.

I am, Sir, yours respectfully,

(Signed) M. Rochford.

I have given the following analyses in detail, for the information of those who may require it. The abstract on page 22 gives a summary of the total results.

The analyses of the samples contaminated with sewage have not, of course, been included: they do not afford any information as to *either* process. About thirty samples, *i.e.*, ten each, of sewage, lime, and A. B. C. have been omitted.

The solid matter has been dried in the usual way at 302 deg. Fahr. The organic matter is determined in the usual way by incineration. All the results are given in grains per Imperial gallon. Some uncertainty exists as to *a few* of the ammonia determinations, from the following cause. The A. B. C. compound gradually produces ammonia from the organic matter in the water; so that a determination made some ten days after the experiment showed more ammonia than was originally present in the sewage. Unless the determination is made within a few hours it is worthless. I consider this property of the A. B. C. most valuable, since it enables the plants on a river-bed to assimilate readily the small amount of injurious matter remaining in the

water. The samples, Nos. 23—30, show the gradual improvement after an admixture of sewage.

The analysis of the residuum is from a mixture of 12 small samples, taken from different parts of the bulk.

G. W. WIGNER.

Camberwell, 9th Oct., 1868.

AVERAGES OF ANALYSES.

TOTTENHAM EXPERIMENTS.

	Average sewage.	Avge. A.B C. water from sewage.	Tottenham drinking water.
Total solid matter grs. per gallon	203·89	81·96	48·70
Organic matter......	109·20	14·62	11·31
Ammonia	3·970	·584	·17
Phosphoric acid......	7·23	—	—
Common salt........	57·10	57·51	9·21
Silica, alumina, and various salts	30·36	9·82	28·18

Tottenham Sewage Residue or Manure.

Water	4·45
Organic matter	20·05
Phosphoric acid	5·33
Sulphate of lime......................	1·67
Silica, alumina, &c.	68·50
	100·00
Nitrogen Ammonia..................	2·37

LEICESTER EXPERIMENTS.

	Average of 42 samples of sewage.	Average of 52 samples lime purified.	Average of 52 samples A.B.C. purified.
Total solid matter	102·74	69·53	72·14
Organic matter	43·02	16·18	9·69
Mineral matter	59·72	53·35	62·45
Ammonia	4·81	3·08	1·76
Chloride of sodium	9·67	12·35	12·35
Nitrogen as nitrites	·16	·79	·09
Oxygen absorbed by organic matter from permanganate	3·754	2·148	·938

Summary.—The lime process removed 62·39 per cent. of the organic matter, and left 37·61 in the water. The A. B. C. process removed 77·48 per cent. of the organic matter, and left 22·52 in the water. Therefore the average lime water contained 67 per cent. more organic matter than the A. B. C. water.

The best lime water contained 11·82 grs. organic; the worst, 28·42 grs. The best A. B. C. water contained 7·16 grs. organic; the worst, 13·31 grs.

Analysis of a Sample drawn from the River Soar, above the Sewer Outfall, Leicester, on August 1, 1868.

	Grs. per imp. gal.
Total solid matter	58·13
Organic matter	14·00
Mineral matter	44·13
Ammonia	9·86
Chloride of sodium	11·64
Nitrogen as nitrites	·624
Oxygen absorbed from permanganate	1·620

ANALYSES OF 42 SAMPLES OF LEICESTER SEWAGE.

Taken at intervals between the 27th July and 1st August, 1868.

Grains per imp. gallon.	No. 1	3	3	4	5	6	7	8	9	10
Total solid matter....	82·40	100·06	107·64	110·15	106·50	100·61	104·37	107·91	97·21	100·88
Organic matter	35·40	39·20	40·31	49·39	48·00	40·10	47·60	42·80	46·61	40·37
Mineral matter	47·00	60·86	67·33	60·76	58·50	60 51	56·77	65·11	50·60	60·51
Ammonia	3·74	11·70	5·40	3·20	3·59	4·60	3·57	5·11	3·58	4·60
Chloride of sodium ..	9·05	9·06	9·27	9·70	9·70	9·75	9·68	9·60	9·63	9·75
Nitrogen as nitrites ..	·612	·240	·237	·190	·190	·191	·185	·187	·178	·191
Oxygen absorbed by organic matter from permanganate	4·900	3·900	3·897	4·261	4·116	3·300	4·100	3·900	4·082	3·300

Grains per imp. gallon.	11	12	13	14	15	16	17	18	19	20
Total solid matter....	99·18	94·32	110·14	100·05	92·45	110·13	93·11	102.20	102·26	114·37
Organic matter	46·62	34·17	48·84	37·40	32·69	49·75	34·71	47·16	47·93	46·25
Mineral matter	52·56	60·15	61·30	62·65	59·76	60·38	58·40	55.04	54·33	68·12
Ammonia	3·68	4·60	3·71	11·51	16·61	3·87	2·19	3·29	3·29	3·47
Chloride of sodium ..	9·72	9·77	9·72	8·77	9·26	9·70	9·11	9·65	9·00	9·91
Nitrogen as nitrites ..	.181	·193	·194	·253	·245	·193	·116	·180	·118	·196
Oxygen absorbed by organic matter from permanganate	4·080	3·200	4·221	3·860	3·937	4·239	3·200	4·000	3·163	4·071

Analyses of Samples of Leicester Sewage—Continued.

Grains per imp. gal.	21	22	23	25	25	26	27	28	29	30	31
Total solid matter	97·21	100·86	100·91	107·16	104·21	100·67	99·27	94·26	94·33	98·21	122·01
Organic matter ..	46·61	40·29	36·21	41·68	40.19	40·62	46·92	44·11	44·11	41·28	46·90
Mineral matter ..	50·60	60·57	64·70	65·48	64·02	60·05	52·35	50·15	50·22	56·93	75·11
Ammonia........	3·58	4·42	4·35	4·97	4·46	4·20	1·16	1.23	1·19	1·18	11·60
Chloride of sodium	9·63	9·84	9·62	9·63	9·66	9·57	9·00	9·17	9 11	9·09	9·07
Nitrogen as nitrites	·178	·191	·191	·194	·191	·187	·101	·111	·100	·116	·112
Oxygen absorbed by organic matter from permanganate	4·082	3·360	3·180	3·390	3·200	3·200	4·261	4·113	3·900	3·816	3·724

Grains per imp. gal.	32	33	34	35	36	37	38	39	40	41	42
Total solid matter	116·36	115·29	101·47	100·34	97·23	109·11	92·16	100·83	107·92	100·90	118·62
Organic matter ..	39·71	36·67	33·63	36·69	38·17	38·51	39·70	49·16	61·13	49·12	60·11
Mineral matter ..	76·65	78·62	67·84	63·65	59·06	70·60	52·46	51·67	46·79	51·78	58·51
Ammonia........	6·71	5·69	4·65	6·51	4·24	4·19	4·37	4·62	4·11	4·62	4·71
Chloride of sodium	11·69	12·37	12·82	11·91	9·31	9·29	9·46	9·39	9·18	9·39	8·16
Nitrogen as nitrites	·069	·081	·113	·072	·18	·01	·01	·00	·01	·17	·03
Oxygen absorbed by organic matter from permanganate	3·113	3·479	3·216	3·417	3·270	3·290	3·216	3·113	4·597	4·681	4·732

LEICESTER EXPERIMENTS.—ANALYSES OF LIME-PURIFIED SEWAGE.

Taken at intervals between 27th July and 1st August.

Grains per imperial gallon.	1	2	3	4	5	6	7	8	9
Total solid matter......	59·36	60·11	60·84	61·30	61·11	61·02	68·07	69·84	73·78
Organic matter........	13·79	13·87	13·61	13·57	13·51	14·11	16·19	15·37	17·85
Mineral matter........	45·57	46·24	47·23	47·73	47·60	46·91	51·88	54·47	55·93
Ammonia	1·71	1·36	1·39	1·57	1·69	2·16	3·47	4·02	3·80
Chloride of sodium	12·00	12·20	12·20	12·60	11·76	11·90	11·80	12·00	12·96
Nitrogen as nitrites	1·19	1·62	1·37	1·43	1·61	1·16	1·97	2·11	1·11
Oxygen absorbed from Permanganate	1·860	1·867	1·864	1·858	1·830	1·921	1·980	2·070	2·116

Grains per imperial gallon.	10	11	12	13	14	15	16	17	18
Total solid matter......	78·22	76·44	79·68	81·20	73·12	73·20	73·33	73 30	73·23
Organic matter........	18·16	21·13	24·36	28·42	15·11	15·20	15·33	15·51	15·79
Mineral matter........	60 06	55·31	55 32	52·78	58·01	58·00	58.00	57·79	57·44
Ammonia	2·11	2·85	5.61	6·14	3·37	2·16	1·22	1·24	1·29
Chloride of sodium	12·64	12·48	12·42	12·48	12·40	12·50	12·60	12·50	12·48
Nitrogen as nitrites	1·33	1·19	1·11	1·17	·07	·63	·09	·03	·06
Oxygen absorbed from Permanganate	2·134	2·169	3·426	3·972	2·013	2·056	2·071	2·111	2·161

Grains per imperial gallon.	19	20	21	22	23	24	25	26
Total solid matter......	73·20	73·23	71·10	67·21	69·46	62·00	62·30	72.11
Organic matter........	15·41	15·22	21·10	15·42	14·11	12·98	13·71	11·82
Mineral matter........	57·79	58·01	50·00	51·79	55·35	49·02	48 59	60·29
Ammonia	1·32	1·18	6·46	6·27	5·19	5·62	4·37	2.47
Chloride of sodium	12·50	12·60	12·40	12·10	12·62	12·48	12·24	12·31
Nitrogen as nitrites	·04	·01	·02	·68	·09	·09	·42	·07
Oxygen absorbed from Permanganate	2·159	1·987	2·220	2·064	1·834	1·860	2·613	1.619

Each sample was a mixture of two samples taken at intervals of about one hour.

LEICESTER EXPERIMENTS.—ANALYSES OF 50 SAMPLES OF A. B. C. PURIFIED WATER.

Taken at intervals between 26th July and 1st August.

Grains per imperial gallon.	1	2	3	4	5	6	7	8
Total solid matter......	71·24	72·19	72.44	72·15	73·10	74·50	74·13	74·90
Organic matter........	13·31	13·11	12·44	12·89	12·86	10·09	9·13	7·47
Inorganic matter	57·93	59·08	60·00	59·26	60·24	64·41	65·00	67·43
Ammonia	1·42	2·87	2·57	2·18	1·35	1·32	1·50	1·60
Chloride of sodium	12·02	12·02	12·13	12·69	12·46	12·40	12·48	12·40
Nitrogen as nitrites	·057	·031	·016	·013	·013	·003	·007	·020
Oxygen absorbed from Permanganate	·852	·891	·874	·863	·852	·798	·639	·584

Grains per imperial gallon.	9	10	11	12	13	14	15	16
Total solid matter......	73·70	72·61	67·10	68·61	70·14	71 44	72·36	73·12
Organic matter	7·26	7·23	9·14	9·13	7·26	10·62	10·99	9·24
Irorganic matter	66·44	65·38	57 96	59·48	62·88	60·82	61·37	63·88
Ammonia	1·56	1·37	2·50	2·84	2 87	2·91	2·17	1·13
Chloride of sodium	12·40	12·36	12·48	12·48	12·48	12·22	13·44	12·48
Nitrogen as nitrites	·091	·136	·011	·019	·027	·035	·047	·001
Oxygen absorbed from Permanganate	·523	·611	1·362	·984	1·121	1·261	1·311	1·047

Analyses of 50 Samples of A. B. C. Purified Water—Continued.

Grains per imperial gallon.	17	18	19	20	21	22	23	24
Total solid matter......	73·61	73.33	73·47	73·23	73·61	73·23	71·87	72·01
Organic matter	11·01	11·16	11·04	11·31	10·16	9·24	13·23	13·02
Inorganic matter	62·60	62·17	62·43	61·92	63·45	63·99	58·64	58·99
Ammonia	3·47	2·19	1·42	1·19	1·00	3·21	1·11	2·97
Chloride of sodium	12·50	12 60	12·44	12·32	12·61	12·40	12·10	11·98
Nitrogen as nitrites	·003	·071	·076	·012	·014	·019	·047	·019
Oxygen absorbed from Permanganate	1·211	1·216	1·211	1·234	1 065	1·021	·894	·891

Grains per imperial gallon.	25	26	27	28	29	30	31	32
Total solid matter......	73·11	73·21	73·00	74·60	74·20	73·65	72·64	72·69
Organic matter	12·31	12·28	12·82	10·11	7·91	7·29	7·28	8·13
Inorganic matter	60·80	60·93	60·18	64·49	66·29	66·36	65·36	64·56
Ammonia	2·28	1·39	1·16	1·50	1·50	1·63	1·44	1.09
Chloride of sodium	12·20	12·49	12·37	12·45	12·40	12·42	12·36	12·10
Nitrogen as nitrites	·016	·012	·016	·006	·011	·070	·107	·08
Oxygen absorbed from Permanganate	·871	·858	·870	·647	·621	·519	·581	·712

Analyses of 50 Samples of A. B. C. Purified Water—Continued.

Grains per imperial gallon.	33	34	35	36	37	38	39	40	41
Total solid matter......	73·61	74·87	72·00	72·80	72·61	73·47	71·39	72·00	71·13
Organic matter........	9·07	11·31	7·62	7·17	7·19	7·43	7·61	7·42	7·87
Inorganic matter	64·54	63·56	64·38	65·63	65·42	66·04	63·78	64·58	63·26
Ammonia	·61	·34	·27	·82	·97	1·91	2·16	1·83	1·91
Chloride of sodium	12·10	12·30	12·20	12·16	12·30	12.30	12·30	12.32	12·30
Nitrogen as nitrites	·01	·01	·02	·11	·00	·01	·04	·07	·00
Oxygen absorbed from Permanganate	·714	·616	·621	·619	·634	·616	·725	·632	·630

Grains per imperial gallon.	42	43	44	45	46	47	48	49	50*
Total solid matter......	71·11	70·00	70 44	66·19	68·72	64·13	65·21	68·32	83·60
Organic matter........	8·11	9·06	9·14	7·16	7·34	7·22	7·25	7·97	18·01
Inorganic matter	63·00	60·94	61·30	59·03	61·38	56·91	57·96	60·35	65·59
Ammonia	2·27	1·98	·96	1·13	1·84	1·11	·96	·61	5·79
Chloride of sodium	12·30	12·26	12·24	12·26	12·33	12·30	12·24	12·24	12·16
Nitrogen as nitrites	·00	·00	·11	·16	·08	·07	·16	·11	1·87
Oxygen absorbed from Permanganate	·972	1·070	1·311	1·216	1·248	1·113	1·076	1·934	2·163

* This sample is contaminated with sewage.

Leamington Experiments.

Grains per imp. gall.	No. 1 Sewage.	No. 1 A.B.C.	No. 2 Sewage.	No. 2 A.B.C.
Total solid matter ..	264·6	74·8	95·0	91·02
Mineral matter	153·2	58·2	67·4	83·68
Organic matter	111·4	16·6	27.6	7·34
Nitrogen as nitrites..	7·61	·14	1·225	·075
Ammonia	5·44	1·7	6.20	1.13
Oxygen absorbed by organic matter	17·44	1·88	2·76	·968

Leamington Residuum.

Water	6·76
Organic matter	29·42
Alkaline Salts........................	13·71
Earthy salts, containing phosphoric acid=1·17	23·83
Silica	26·28
	100·00
Nitrogen = ammonia	3·79

Leicester Residuum, dried in bulk at Leicester.

Water	13·79
Organic matter	46 93
Alkaline salts	4·97
Earthy salts, containing phosphoric acid=1·31	12 88
Silica	21·43
	100·00
Nitrogen = ammonia	4·67

G. W. WIGNER.